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Yoshikawa

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(54) **FIXING DEVICE AND IMAGE FORMING APPARATUS INCORPORATING SAME**

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(52) **U.S. Cl.**
CPC ***G03G 15/2085*** (2013.01); ***G03G 15/2028*** (2013.01)

(58) **Field of Classification Search**
CPC G03G 15/2028; G03G 15/2085
USPC 399/323
See application file for complete search history.

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(57) **ABSTRACT**

A fixing device includes a separator disposed downstream from a fixing nip formed between a fixing rotary body and a pressing rotary body in a recording medium conveyance direction to separate a recording medium from the fixing rotary body. The separator includes a front disposed opposite an outer circumferential surface of the fixing rotary body with a given interval therebetween and a conveyance face contiguous to the front, over which the recording medium slides. A coating layer, made of fluoroplastic, coats the front and the conveyance face of the separator. The coating layer includes a front portion corresponding to the front of the separator and produced with a plurality of recesses extending in a width direction of the separator orthogonal to the recording medium conveyance direction throughout substantially an entire width of the separator in the width direction thereof.

19 Claims, 6 Drawing Sheets

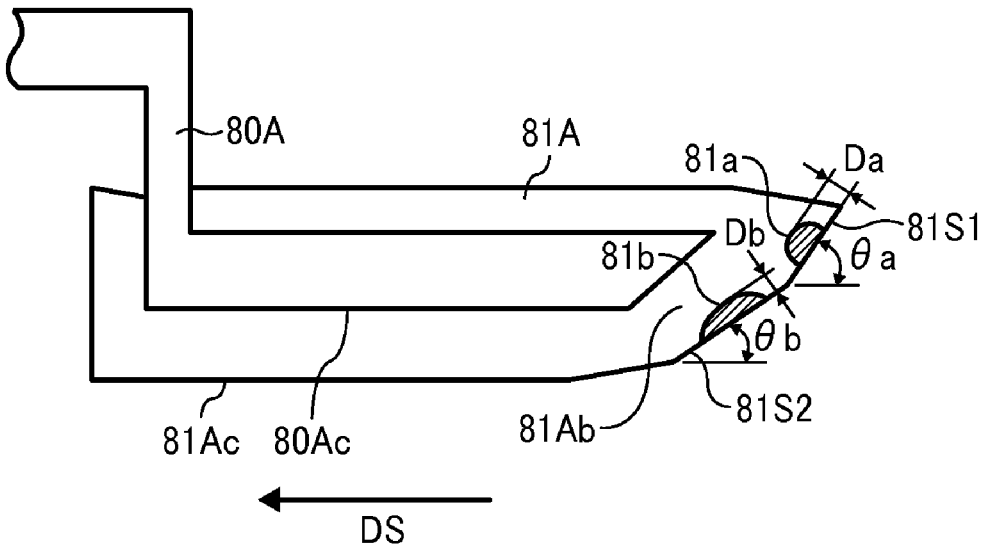


FIG. 1

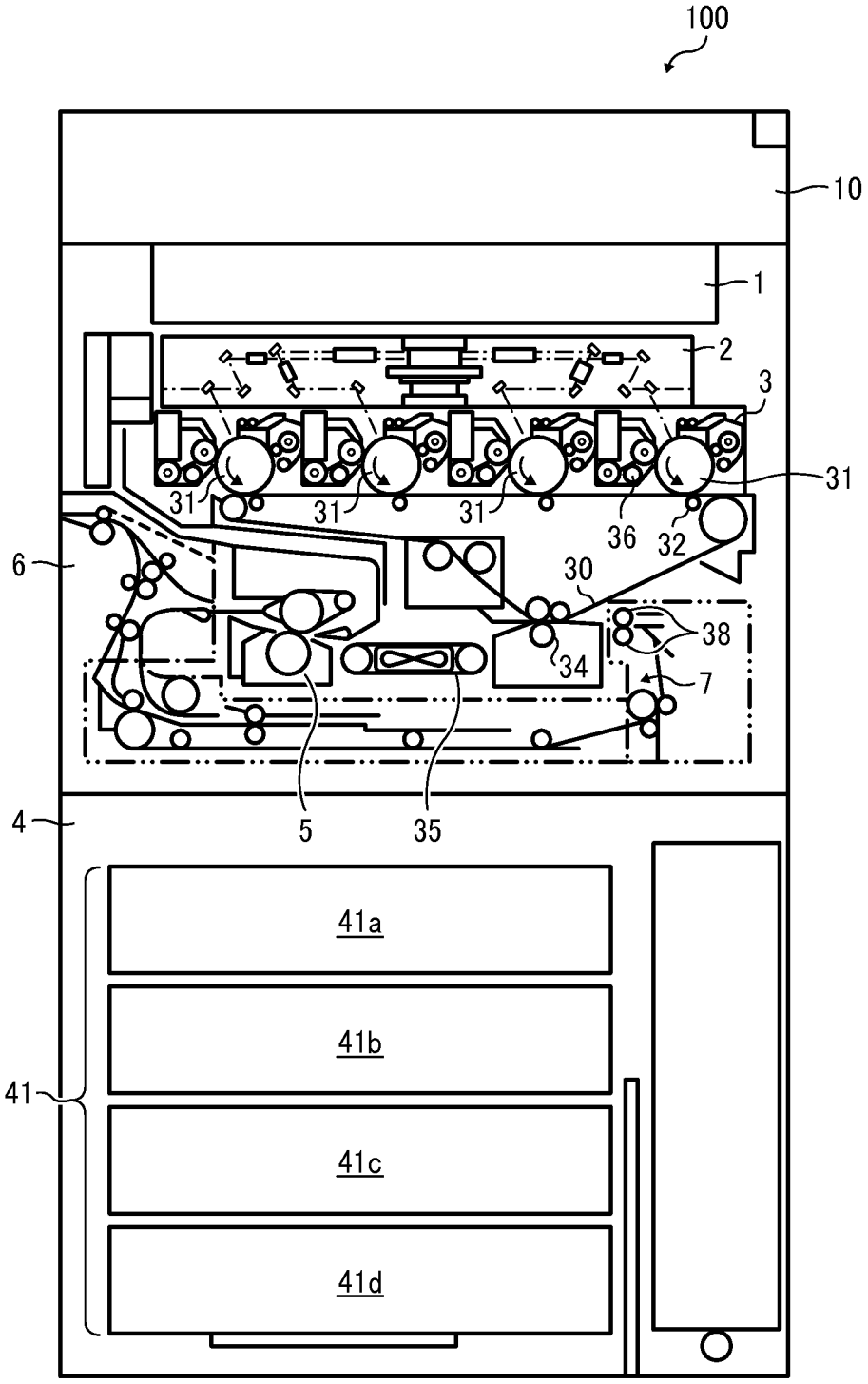


FIG. 2

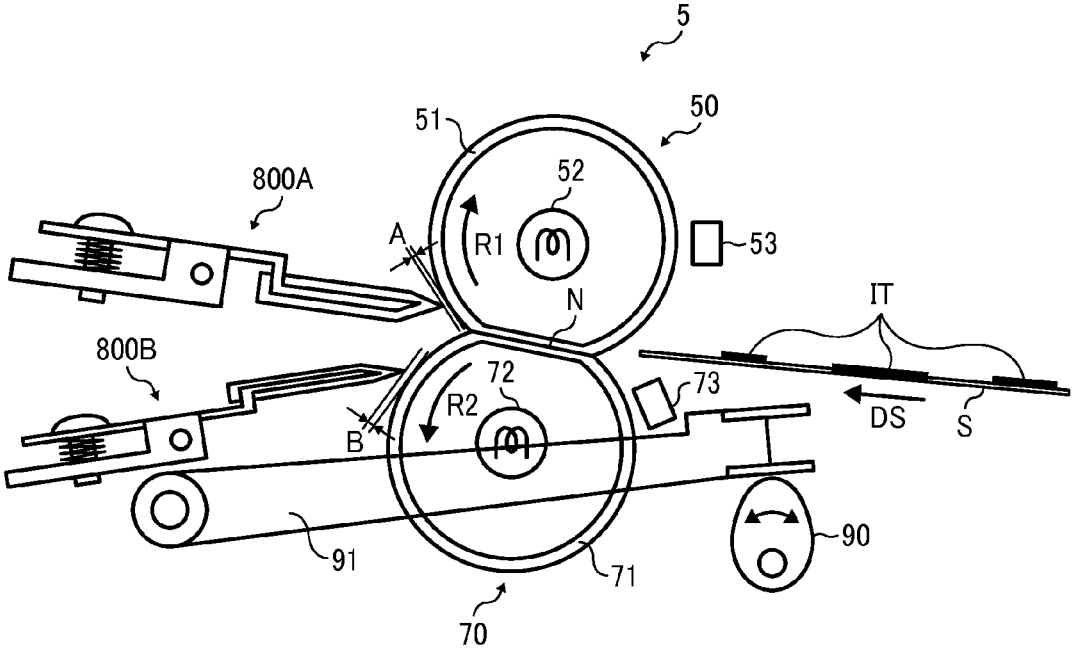

5
51
50
52
800A
A
R1
53
N
IT
800B
72
73
R2
B
DS
S
91
71
90
70

FIG. 3

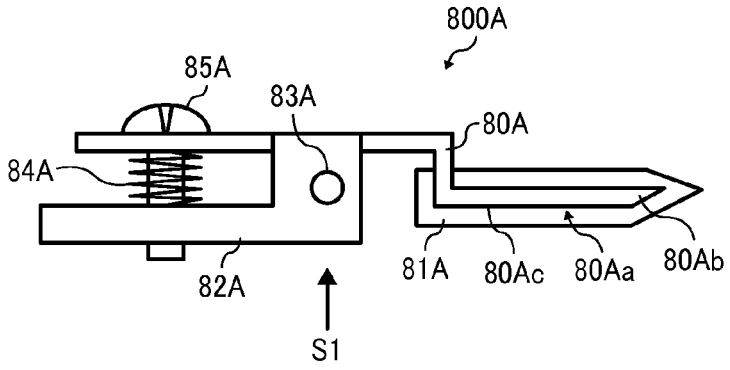

800A
85A
83A
80A
84A
81A
80Ac
80Aa
80Ab
82A
S1

FIG. 4

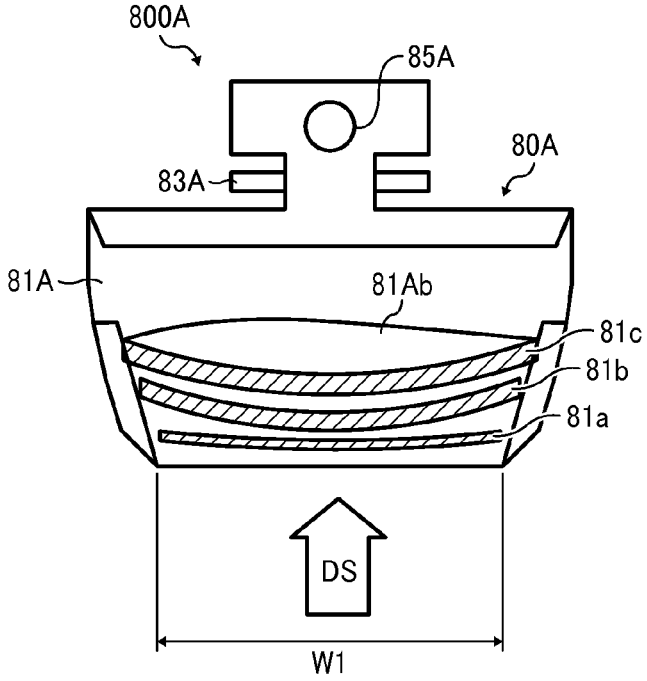


FIG. 5

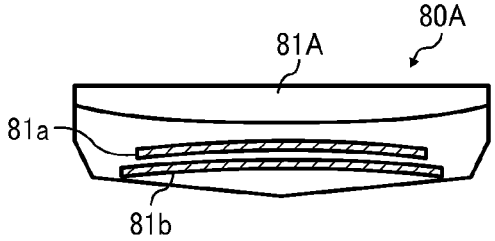


FIG. 6

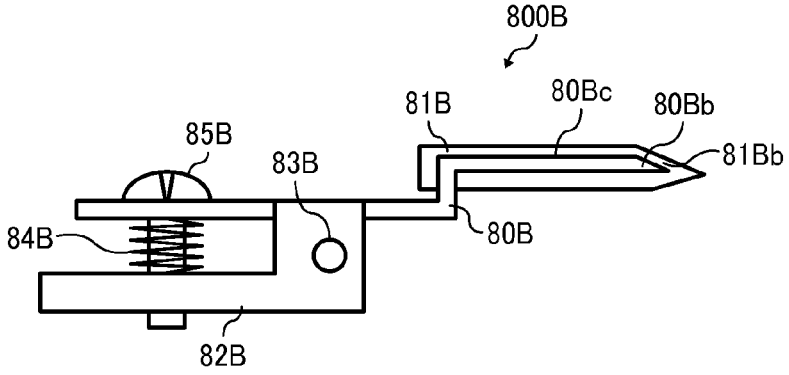


FIG. 7

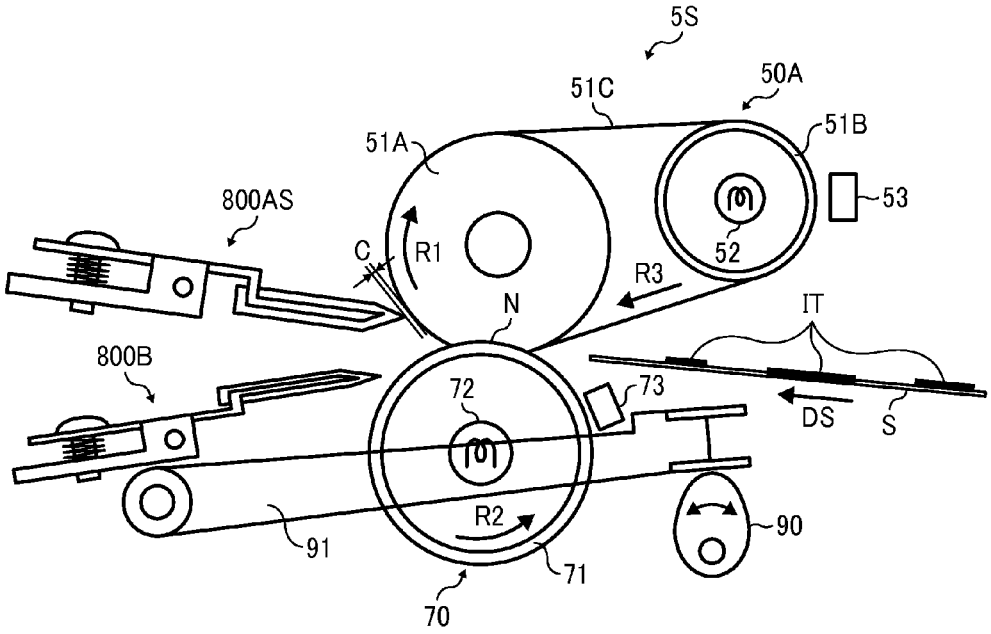

5S
51C
50A
51B
51A
800AS
53
C
R1
52
R3
N
IT
800B
72
73
DS
S
R2
90
91
71
70

FIG. 8

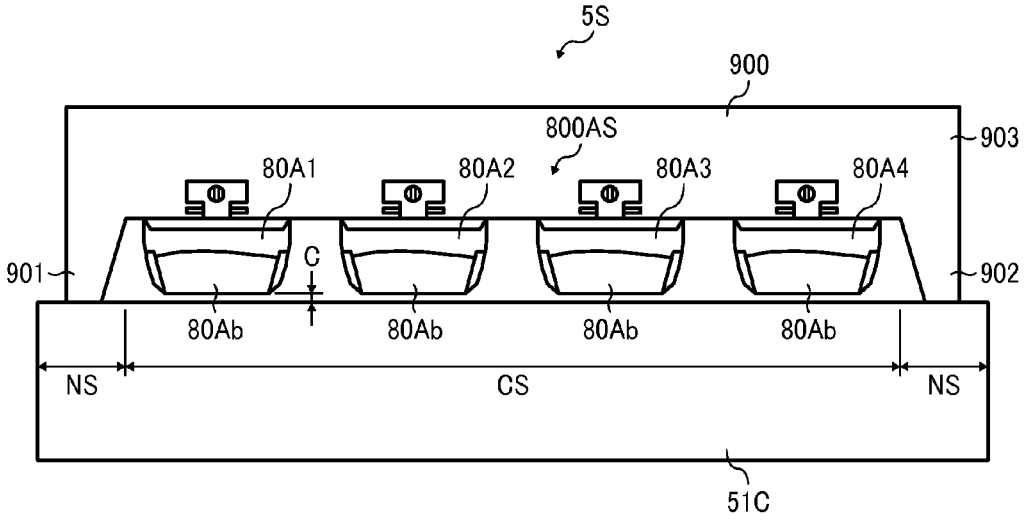

5S
900
800AS
903
80A1
80A2
80A3
80A4
901
C
902
80Ab
80Ab
80Ab
80Ab
NS
CS
NS
51C

FIG. 9

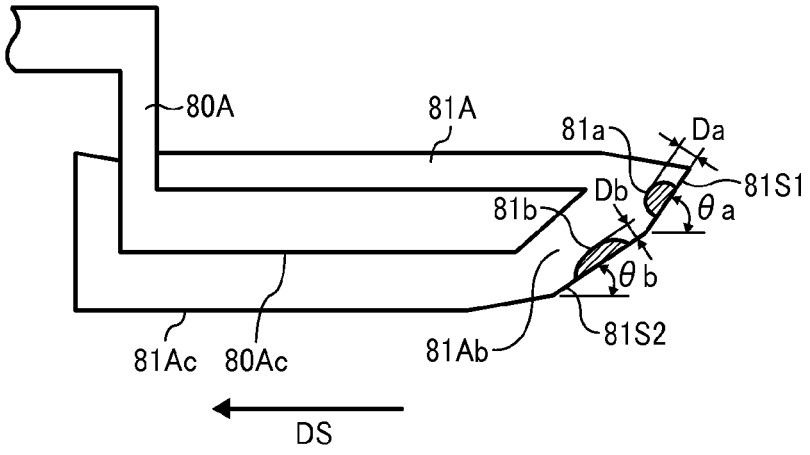

80A
81A
81a
Da
81S1
Db
81b
θ a
θ b
81S2
81Ab
81Ac
80Ac
DS

FIG. 10

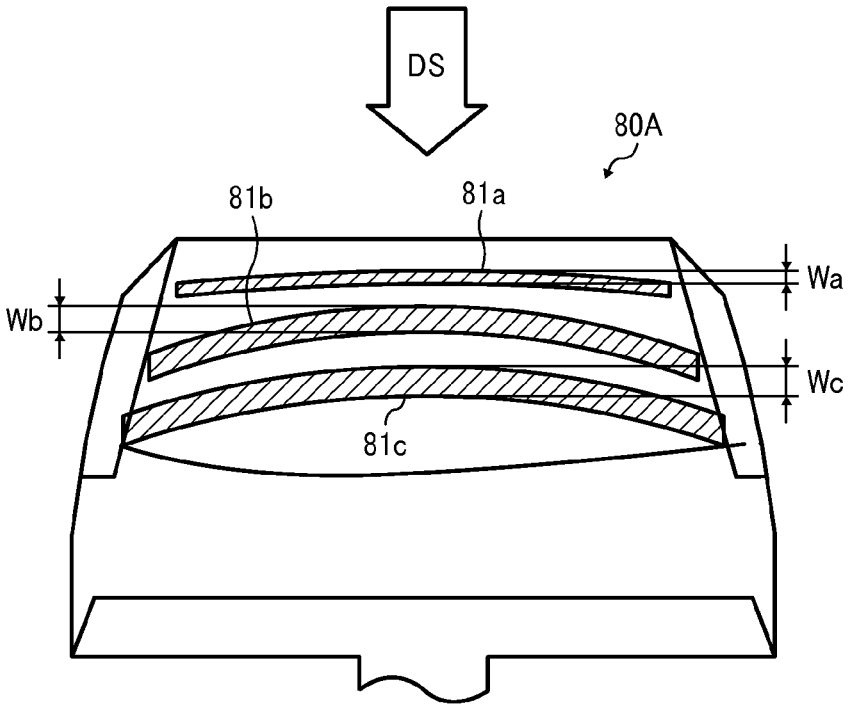

DS
80A
81b
81a
Wa
Wb
Wc
81c

FIG. 11A

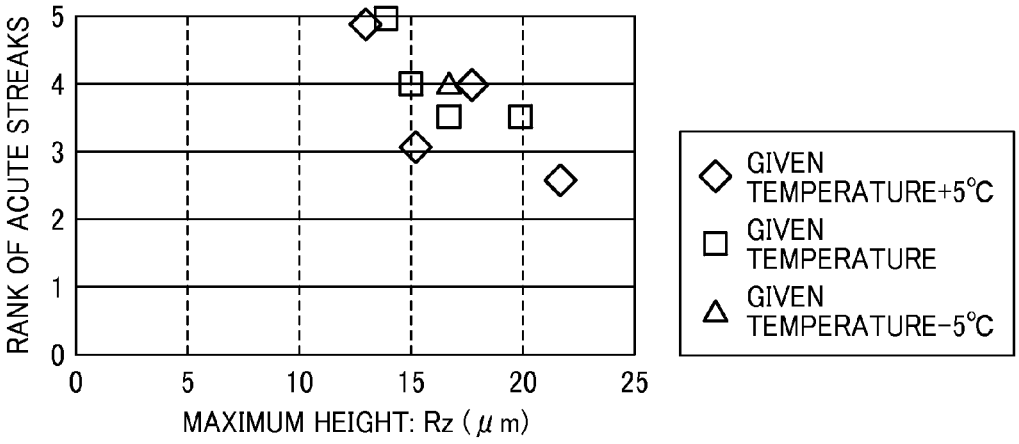
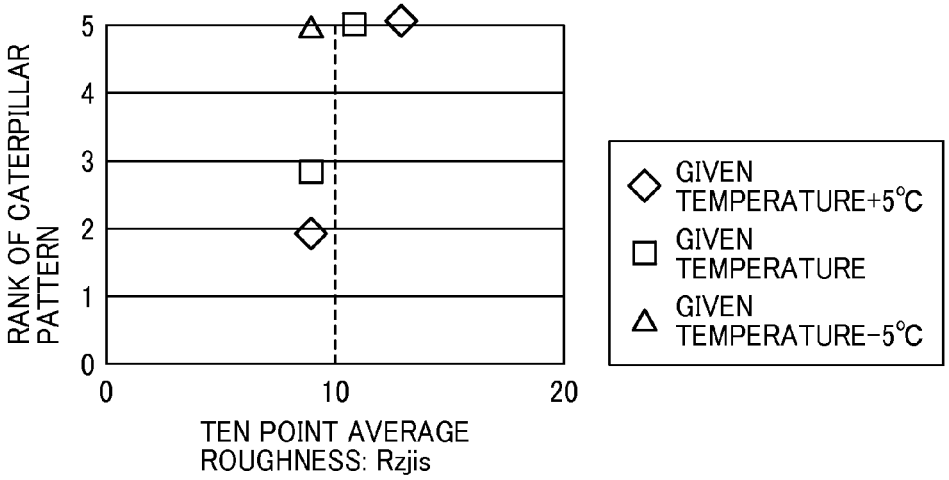


FIG. 11B



FIXING DEVICE AND IMAGE FORMING APPARATUS INCORPORATING SAME

CROSS-REFERENCE TO RELATED APPLICATION

This patent application is based on and claims priority pursuant to 35 U.S.C. §119 to Japanese Patent Application No. 2012-129279, filed on Jun. 6, 2012, in the Japanese Patent Office, the entire disclosure of which is hereby incorporated by reference herein.

BACKGROUND OF THE INVENTION

1. Field of the Invention

Example embodiments generally relate to a fixing device and an image forming apparatus, and more particularly, to a fixing device for fixing an image on a recording medium and an image forming apparatus incorporating the fixing device.

2. Description of the Related Art

Related-art image forming apparatuses, such as copiers, facsimile machines, printers, or multifunction printers having at least one of copying, printing, scanning, and facsimile functions, typically form an image on a recording medium according to image data. Thus, for example, a charger uniformly charges a surface of a photoconductor; an optical writer emits a light beam onto the charged surface of the photoconductor to form an electrostatic latent image on the photoconductor according to the image data; a development device supplies toner to the electrostatic latent image formed on the photoconductor to render the electrostatic latent image visible as a toner image; the toner image is directly transferred from the photoconductor onto a recording medium or is indirectly transferred from the photoconductor onto a recording medium via an intermediate transfer belt; finally, a fixing device applies heat and pressure to the recording medium bearing the toner image to fix the toner image on the recording medium, thus forming the image on the recording medium.

Such fixing device may include a fixing roller and a pressing roller pressed against the fixing roller to form a fixing nip therebetween through which the recording medium bearing the toner image passes. As the fixing roller heated by a heater and the pressing roller rotate and convey the recording medium through the fixing nip, they apply heat and pressure to the recording medium, thus fixing the toner image on the recording medium.

After being discharged from the fixing nip, the recording medium separates from the fixing roller by its rigidity. However, if the recording medium is thin and soft, it may not separate from the fixing roller readily and therefore may be wound around the fixing roller. To address this circumstance, a separator may be disposed downstream from the fixing nip in a recording medium conveyance direction to contact and separate the recording medium from the fixing roller.

However, if the thin, soft recording medium bears a solid toner image, the solid toner image, immediately after being discharged from the fixing nip, may not be cooled sufficiently and therefore molten toner of the solid toner image may adhere the recording medium to the separator. To address this circumstance, the separator may be coated with a fluoroplastic layer that facilitates separation of the solid toner image on the thin, soft recording medium from the separator.

However, as the thin, soft recording medium bearing the solid toner image slides over the fluoroplastic layer coating the separator, the solid toner image may be caught in the fluoroplastic layer and therefore the thin, soft recording medium may be tucked. As the solid toner image is caught in the fluoroplastic layer repeatedly, the solid toner image on the tucked recording medium may be deformed into a caterpillar pattern. For example, a section of the solid toner image caught and adhered to the fluoroplastic layer may be damaged while another section of the solid toner image not adhered to the fluoroplastic layer may be clean. Thus, the damaged section and the clean section of the solid toner image, as they are repeatedly produced, may form a faulty caterpillar pattern on the shin, soft recording medium.

SUMMARY OF THE INVENTION

At least one embodiment may provide a fixing device that includes a fixing rotary body rotatable in a given direction of rotation. A pressing rotary body is pressed against the fixing rotary body to form a fixing nip therebetween through which a recording medium is conveyed. A separator is disposed downstream from the fixing nip in a recording medium conveyance direction to separate the recording medium discharged from the fixing nip from the fixing rotary body. The separator includes a front disposed opposite an outer circumferential surface of the fixing rotary body with a given interval therebetween and a conveyance face contiguous to the front, over which the recording medium slides. A coating layer, made of fluoroplastic, coats the front and the conveyance face of the separator. The coating layer includes a front portion corresponding to the front of the separator and produced with a plurality of recesses extending in a width direction of the separator orthogonal to the recording medium conveyance direction throughout substantially an entire width of the separator in the width direction thereof.

At least one embodiment may provide an image forming apparatus including the fixing device described above.

Additional features and advantages of example embodiments will be more fully apparent from the following detailed description, the accompanying drawings, and the associated claims.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

A more complete appreciation of example embodiments and the many attendant advantages thereof will be readily obtained as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings, wherein:

FIG. **1** is a schematic vertical sectional view of an image forming apparatus according to an example embodiment of the present invention;

FIG. **2** is a vertical sectional view of a fixing device according to a first example embodiment of the present invention that is installed in the image forming apparatus shown in FIG. **1**;

FIG. **3** is a vertical sectional view of a separation assembly incorporated in the fixing device shown in FIG. **2**;

FIG. **4** is a plan view of a separator incorporated in the separation assembly shown in FIG. **3**;

FIG. **5** is a partial plan view of the separator shown in FIG. **4** illustrating recesses mounted thereon;

FIG. **6** is a vertical sectional view of a guide assembly incorporated in the fixing device shown in FIG. **2**;

FIG. **7** is a vertical sectional view of a fixing device according to a second example embodiment of the present invention that is installable in the image forming apparatus shown in FIG. **1**;

FIG. **8** is a partial plan view of the fixing device shown in FIG. **7** illustrating separators and a support incorporated therein;

FIG. **9** is a partial vertical sectional view of the separator shown in FIG. **4**;

FIG. **10** is a partial plan view of the separator shown in FIG. **9**;

FIG. **11**A is a graph showing a relation between the maximum height of a coating layer coating the separator shown in FIG. **9** and the rank of acute streaks that appear on a toner image on a recording medium sliding over the coating layer; and

FIG. **11**B is a graph showing a relation between the ten point average roughness Rzjis of a coating layer coating the separator shown in FIG. **9** and the rank of a caterpillar pattern that appears on a toner image on a recording medium sliding over the coating layer.

The accompanying drawings are intended to depict example embodiments and should not be interpreted to limit the scope thereof. The accompanying drawings are not to be considered as drawn to scale unless explicitly noted.

DETAILED DESCRIPTION OF THE INVENTION

It will be understood that if an element or layer is referred to as being "on", "against", "connected to", or "coupled to" another element or layer, then it can be directly on, against, connected or coupled to the other element or layer, or intervening elements or layers may be present. In contrast, if an element is referred to as being "directly on", "directly connected to", or "directly coupled to" another element or layer, then there are no intervening elements or layers present. Like numbers refer to like elements throughout. As used herein, the term "and/or" includes any and all combinations of one or more of the associated listed items.

Spatially relative terms, such as "beneath", "below", "lower", "above", "upper", and the like, may be used herein for ease of description to describe one element or feature's relationship to another element(s) or feature(s) as illustrated in the figures. It will be understood that the spatially relative terms are intended to encompass different orientations of the device in use or operation in addition to the orientation depicted in the figures. For example, if the device in the figures is turned over, elements described as "below" or "beneath" other elements or features would then be oriented "above" the other elements or features. Thus, term such as "below" can encompass both an orientation of above and below. The device may be otherwise oriented (rotated 90 degrees or at other orientations) and the spatially relative descriptors used herein are interpreted accordingly.

Although the terms first, second, etc. may be used herein to describe various elements, components, regions, layers and/or sections, it should be understood that these elements, components, regions, layers and/or sections should not be limited by these terms. These terms are used only to distinguish one element, component, region, layer, or section from another region, layer, or section. Thus, a first element, component, region, layer, or section discussed below could be termed a second element, component, region, layer, or section without departing from the teachings of the present invention.

The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of the present invention. As used herein, the singular forms "a", "an", and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms "includes" and/or "including", when used in this specification, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof.

In describing example embodiments illustrated in the drawings, specific terminology is employed for the sake of clarity. However, the disclosure of this specification is not intended to be limited to the specific terminology so selected and it is to be understood that each specific element includes all technical equivalents that operate in a similar manner.

Referring now to the drawings, wherein like reference numerals designate identical or corresponding parts throughout the several views, particularly to FIG. **1**, an image forming apparatus **100** according to an example embodiment is explained.

FIG. **1** is a schematic vertical sectional view of the image forming apparatus **100**. The image forming apparatus **100** may be a copier, a facsimile machine, a printer, a multifunction printer (MFP) having at least one of copying, printing, scanning, plotter, and facsimile functions, or the like. According to this example embodiment, the image forming apparatus **100** is a digital color copier that forms color and monochrome toner images on recording media by electrophotography.

As shown in FIG. **1**, the image forming apparatus **100** includes a scanner **1** located in an upper portion of the image forming apparatus **100** to optically read an image on an original conveyed from an auto document feeder (ADF) **10** situated above the scanner **1** into color image data. The ADF **10** loads and feeds a plurality of originals continuously to the scanner **1**. Below the scanner **1** is a writer **2** for emitting light that optically scans four photoconductive drums **31**.

For example, the writer **2** emits light onto the uniformly charged, four photoconductive drums **31** according to respective black, magenta, yellow, and cyan image data constituting the color image data created by and sent from the scanner **1** or color image data sent from an external device such as a client computer, thus forming electrostatic latent images on the photoconductive drums **31**, respectively.

Taking one of the four photoconductive drums **31** that forms a black toner image, for example, a development device **3** visualizes the electrostatic latent image formed on the photoconductive drum **31** into a black toner image. The black toner image formed on the photoconductive drum **31** is primarily transferred onto an intermediate transfer belt **30** by a primary transfer roller **32** disposed opposite the photoconductive drum **31** via the intermediate transfer belt **30**. Similarly, other three development devices **3** visualize the electrostatic latent images formed on the corresponding photoconductive drums **31** into magenta, yellow, and cyan toner images that are primarily transferred onto the intermediate transfer belt **30**. Thus, the black, magenta, yellow, and cyan toner images are primarily transferred and superimposed onto a same position on the intermediate transfer belt **30**, forming a color toner image thereon. After the primary transfer of the black toner image, a cleaner **36** removes residual black toner failed to be transferred onto the intermediate transfer belt **30** and therefore remaining on the photoconductive drum **31** therefrom. Similarly, residual magenta, yellow, and cyan toners remaining on the other three photoconductive drums **31** are removed therefrom.

A sheet feeder **4** is located in a lower portion of the image forming apparatus **100**. The sheet feeder **4** includes a paper tray set **41** constructed of four paper trays **41***a*, **41***b*, **41***c*, and **41***d* that load recording media (e.g., sheets). A recording medium is picked up and conveyed from one of the four paper trays **41***a*, **41***b*, **41***c*, and **41***d* toward a registration roller pair

38 through a conveyance path 7 extending from the paper trays 41*a*, 41*b*, 41*c*, and 41*d* to the registration roller pair 38. After skew correction, the registration roller pair 38 directs and feeds the recording medium to a secondary transfer device 34 contacting the intermediate transfer belt 30 so that the recording medium reaches the secondary transfer device 34 at a time when the color toner image formed on the intermediate transfer belt 30 reaches the secondary transfer device 34. Thus, the secondary transfer device 34 secondarily transfers the color toner image formed on the intermediate transfer belt 30 onto the recording medium.

Downstream from the secondary transfer device 34 in a recording medium conveyance direction is a fixing device 5 that fixes the color toner image on the recording medium. For example, after passing through the secondary transfer device 34, the recording medium bearing the color toner image is conveyed to the fixing device 5 through a conveyance belt 35 interposed between the secondary transfer device 34 and the fixing device 5 in the recording medium conveyance direction. The fixing device 5 applies heat and pressure to the recording medium, thus fixing the color toner image on the recording medium. Thereafter, the recording medium bearing the fixed color toner image is discharged from the image forming apparatus 100 through an outlet 6. Thus, a series of image forming processes to form the color toner image on the recording medium is completed.

With reference to FIG. 2, a description is provided of a construction of the fixing device 5 according to a first example embodiment that is incorporated in the image forming apparatus 100 described above.

FIG. 2 is a vertical sectional view of the fixing device 5. As shown in FIG. 2, the fixing device 5 (e.g., a fuser) includes a fixing assembly 50 and a pressing assembly 70 pressed against the fixing assembly 50 to form a fixing nip N therebetween through which a recording medium S bearing a toner image IT is conveyed. As the recording medium S is conveyed through the fixing nip N, the fixing assembly 50 and the pressing assembly 70 apply heat and pressure to the recording medium S to fix the toner image IT on the recording medium S.

A detailed description is now given of a construction of the fixing assembly 50.

The fixing assembly 50 includes a hollow fixing roller 51 serving as a fixing rotary body rotatable in a rotation direction R1 and a heater 52 (e.g., a heat source) disposed inside and heating the fixing roller 51. The fixing roller 51 is constructed of a metal core, an elastic layer coating the metal core and made of silicone rubber, and a surface release layer coating the elastic layer and made of fluoroplastic.

A detailed description is now given of a construction of the pressing assembly 70.

The pressing assembly 70 includes a hollow pressing roller 71 serving as a pressing rotary body rotatable in a rotation direction R2 counter to the rotation direction R1 of the fixing roller 51 and a heater 72 disposed inside and heating the pressing roller 71. The pressing roller 71 is constructed of a metal core, an elastic layer coating the metal core and made of rubber, and a surface release layer coating the elastic layer and made of fluoroplastic.

A temperature sensor 53 is disposed opposite an outer circumferential surface of the fixing roller 51 to detect the temperature of the fixing roller 51. Similarly, a temperature sensor 73 is disposed opposite an outer circumferential surface of the pressing roller 71 to detect the temperature of the pressing roller 71. A controller (e.g., a processor), that is, a central processing unit (CPU) provided with a random-access memory (RAM) and a read-only memory (ROM), for example, is operatively connected to the heaters 52 and 72 and the temperature sensors 53 and 73. The controller controls the heaters 52 and 72 based on the temperature of the fixing roller 51 detected by the temperature sensor 53 and the temperature of the pressing roller 71 detected by the temperature sensor 73 so as to adjust the temperature of each of the fixing roller 51 and the pressing roller 71 to a desired fixing temperature. For example, the temperature sensor 53 includes a plurality of sensors disposed opposite a center and a lateral end of the fixing roller 51 in a longitudinal direction or an axial direction thereof to detect the temperature of the center and the lateral end of the fixing roller 51.

The pressing roller 71 is contacted by a lever 91 that is swingable as it is lifted or lowered by a cam 90 rotatably contacting the lever 91. As the cam 90 lifts the lever 91, the lever 91 presses the pressing roller 71 against the fixing roller 51, forming the fixing nip N between the pressing roller 71 and the fixing roller 51 by elastic deformation of the elastic layers of the pressing roller 71 and the fixing roller 51 caused by pressure from the pressing roller 71.

As the recording medium S bearing the toner image IT is conveyed through the fixing nip N while sandwiched between the fixing roller 51 rotating in the rotation direction R1 and the pressing roller 71 rotating in the rotation direction R2, the recording medium S receives heat and pressure from the fixing roller 51 and the pressing roller 71 that melt and fix the toner image IT on the recording medium S. When the recording medium S bearing the fixed toner image IT is discharged from the fixing nip N, it is separated from the fixing roller 51 and conveyed in a recording medium conveyance direction DS.

Immediately after the recording medium S is discharged from the fixing nip N, the toner image IT melted while the recording medium S passes through the fixing nip N is not cooled and solidified. Hence, the recording medium S adheres to the outer circumferential surface of the fixing roller 51 by an adhesive force of molten toner of the toner image IT.

If the recording medium S is rigid enough to overcome the adhesive force of the molten toner, the recording medium S separates from the fixing roller 51. Conversely, if the recording medium S is thin paper that is not rigid enough to overcome the adhesive force of the molten toner or if the toner image IT is a relatively large, solid toner image that has a greater adhesive force, the recording medium S does not have a separation force great enough to separate itself from the fixing roller 51. Accordingly, the recording medium S may not separate from the fixing roller 51 and may be wound around the fixing roller 51. To address this circumstance, a separation assembly 800A and a guide assembly 800B are disposed downstream from the fixing nip N in the recording medium conveyance direction DS.

With reference to FIG. 3, a description is provided of a construction of the separation assembly 800A.

FIG. 3 is a vertical sectional view of the separation assembly 800A. As shown in FIG. 3, the separation assembly 800A includes a bracket 82A and a separator 80A rotatably or swingably attached to the bracket 82A. The separator 80A includes a base 80Aa disposed opposite the fixing roller 51 and made of heat-resistant, rigid resin such as polyether ether ketone (PEEK), polyether ketone (PEK), liquid crystal polymer (LCP), polyphenylene sulfide (PPS) or metal such as aluminum. The base 80Aa is coated with a coating layer 81A made of fluoroplastic.

The base 80Aa includes a front 80Ab disposed opposite the fixing roller 51 with a given slight interval A depicted in FIG. 2 therebetween and a conveyance face 80Ac, contiguous to and disposed downstream from the front 80Ab in the record-

ing medium conveyance direction DS. The recording medium S conveyed between the separation assembly **800**A and the guide assembly **800**B slides over the conveyance face **80**Ac of the base **80**Aa.

According to this example embodiment shown in FIG. **3**, the coating layer **81**A coats the entire base **80**Aa of the separator **80**A. Alternatively, at least the front **80**Ab and the conveyance face **80**Ac of the base **80**Aa that contact the recording medium S conveyed between the separation assembly **800**A and the guide assembly **800**B may be made of or coated with fluoroplastic.

The coating layer **81**A has a smooth surface. Fluoroplastic of the coating layer **81**A may be made of heat-resistant resin that facilitates separation of the toner image IT on the recording medium S from the coating layer **81**A, such as tetrafluoroethylene-perfluoroalkyl vinyl ether copolymer (PFA), tetrafluoroethylene-hexafluoropropylene copolymer (FEP), tetrafluoroethylene ethylene copolymer (ETFE), vinylidene fluoride resin (PVDF), vinyl fluoride resin (PVF), and ethylene-chlorotrifluoroethylene resin (ECTFE).

The separator **80**A is supported by the bracket **82**A serving as a support such that the separator **80**A is pivotable about a pin **83**A attached to the bracket **82**A. The separator **80**A is fastened to the bracket **82**A with a screw **85**A through a compression spring **84**A anchored to the bracket **82**A and the separator **80**A.

By adjusting the screw **85**A, the separator **80**A is swingably positioned with respect to the fixing roller **51** such that the slight interval A of about 0.2 mm, for example, is produced between the front **80**Ab of the separator **80**A and the outer circumferential surface of the fixing roller **51** as shown in FIG. **2**.

A part of the smooth surface of the coating layer **81**A corresponding to the front **80**Ab of the separator **80**A is produced with a plurality of recesses extending in a width direction of the separator **80**A orthogonal to the recording medium conveyance direction DS throughout substantially the entire width of the separator **80**A in the width direction thereof.

With reference to FIGS. **4** and **5**, a detailed description is now given of a construction of the separator **80**A.

FIG. **4** is a plan view of the separator **80**A seen from a direction S**1** depicted in FIG. **3**. As shown in FIG. **4**, three recesses **81***a*, **81***b*, and **81***c* are produced in a front portion **81**Ab constituting the smooth surface of the coating layer **81**A that corresponds to the front **80**Ab of the separator **80**A. The recesses **81***a*, **81***b*, and **81***c* extend in a width direction W**1** of the separator **80**A that is orthogonal to the recording medium conveyance direction DS and parallel to the axial direction of the fixing roller **51** throughout substantially the entire width of the separator **80**A in the width direction W**1** thereof.

FIG. **5** is a partial plan view of the separator **80**A illustrating the recesses **81***a* and **81***b* disposed in proximity to the fixing nip N. It is to be noted that the recess **81***c* is omitted in FIG. **5**.

If the recording medium S is rigid enough to separate from the fixing roller **51**, the recording medium S separates from the fixing roller **51** by its rigidity and is conveyed along the conveyance face **80**Ac of the separator **80**A. Contrarily, if the recording medium S is thin and soft, the recording medium S may not separate from the fixing roller **51** by its rigidity and therefore may require the separator **80**A that facilitates separation of the recording medium S from the fixing roller **51**. That is, the thinner and softer the recording medium S is, more difficult it is for the recording medium S to separate from the fixing roller **51** by its rigidity.

For example, as the recording medium S is thinner and softer, the recording medium S separates from the fixing roller **51** at the position closer to the front **80**Ab of the separator **80**A. Accordingly, as the recording medium S separates from the fixing roller **51** at the position in proximity to the front **80**Ab of the separator **80**A, the recording medium S slides over the front portion **81**Ab of the coating layer **81**A corresponding to the front **80**Ab of the separator **80**A.

For example, if a plurality of projections and recesses is produced in the coating layer **81**A, when a thin, smooth, glossy sheet bearing a solid toner image IT is used as a recording medium S, the solid toner image IT may slide over the projections of the coating layer **81**A with increased friction therebetween, producing acute streaks on the solid toner image IT. To address this circumstance, according to this example embodiment, the smooth surface of the coating layer **81**A coating the separator **80**A does not have partial, slight asperities, that is, projections and recesses. Accordingly, even if the solid toner image IT slides over the coating layer **81**A, the coating layer **81**A does not produce acute streaks on the solid toner image IT.

The front portion **81**Ab of the coating layer **81**A coating the front **80**Ab of the separator **80**A is produced with the plurality of recesses **81***a*, **81***b*, and **81***c*. Accordingly, even if the solid toner image IT on the thin recording medium S slides over the coating layer **81**A coating the separator **80**A in a substantial slide area thereof in the recording medium conveyance direction DS, the plurality of recesses **81***a*, **81***b*, and **81***c* decreases the slide area without obstructing conveyance of the recording medium S, thus preventing formation of a caterpillar pattern on the solid toner image IT effectively.

Further, if a plurality of ribs extending in a slanting direction relative to the recording medium conveyance direction DS is mounted on the separator **80**A, when a sheet bearing a relatively small toner image or a rigid sheet is used as a recording medium S, the toner image may slide over a part of the separator **80**A, that is, the ribs, with increased friction therebetween. Accordingly, a section of the toner image that slides over the ribs may have decreased gloss while another section of the toner image that does not slide over the ribs may have increased gloss, resulting in variation in gloss of the toner image regularly produced in the recording medium conveyance direction DS. To address this circumstance, according to this example embodiment, even if the recording medium S slides over a part of the separator **80**A via the coating layer **81**A, the plurality of recesses **81***a*, **81***b*, and **81***c* produces slide faces between the adjacent recesses **81***a*, **81***b*, and **81***c* that extend substantially evenly in the width direction W**1** of the separator **80**A orthogonal to the recording medium conveyance direction DS, thus preventing variation in gloss of the toner image IT regularly produced in the recording medium conveyance direction DS.

With reference to FIG. **2**, a detailed description is now given of a construction of the guide assembly **800**B.

If there is no possibility that the recording medium S is wound around the pressing roller **71**, it is not necessary for the guide assembly **800**B to have a construction described below with reference to FIG. **6**. In this case, the guide assembly **800**B serves as a guide that contacts and guides a back side of the recording medium S discharged from the fixing nip N that faces the guide assembly **800**B to the outside of the fixing device **5**. That is, the guide assembly **800**B serves as a conveyance path producer that produces a conveyance path extending from the fixing nip N to the outside of the fixing device **5**, through which the recording medium S discharged from the fixing nip N is conveyed.

The recording medium S may be wound around the pressing roller **71** when the image forming apparatus **100** depicted in FIG. **1** performs duplex printing. For example, as a recording medium S bearing a fixed toner image IT on a front side thereof and an unfixed toner image IT on a back side thereof is conveyed through the fixing nip N, the fixed toner image IT on the front side of the recording medium S that contacts the pressing roller **71** may be heated and melted by the pressing roller **71** heated by the heater **72**, generating an adhesive force that adheres the fixed toner image IT to the pressing roller **71**. Thus, the recording medium S may be wound around the pressing roller **71**.

This problem may also arise when a used recording medium bearing a fixed toner image on the front side thereof is used for saving resources. To address this circumstance, the guide assembly **800**B has a construction similar to that of the separation assembly **800**A to facilitate separation of the recording medium S from the pressing roller **71** as shown in FIG. **6**.

FIG. **6** is a vertical sectional view of the guide assembly **800**B. As shown in FIG. **6**, similarly to the separation assembly **800**A depicted in FIG. **3**, the guide assembly **800**B, serving as a separation assembly that separates the recording medium S from the pressing roller **71** as well as a guide assembly that guides the recording medium S, includes a bracket **82**B and a separator **80**B rotatably or swingably attached to the bracket **82**B. The separator **80**B is supported by the bracket **82**B such that the separator **80**B is pivotable about a pin **83**B. The separator **80**B is fastened to the bracket **82**B by a screw **85**B through a compression spring **84**B.

By adjusting the screw **85**B, the separator **80**B is swingably positioned with respect to the pressing roller **71** such that a given slight interval B of about 0.2 mm, for example, is produced between a front **80**Bb of the separator **80**B and the outer circumferential surface of the pressing roller **71** as shown in FIG. **2**.

Similarly to the separator **80**A depicted in FIG. **3**, the front **80**Bb of the separator **80**B disposed opposite the pressing roller **71** is coated with a coating layer **81**B made of fluoroplastic. A front portion **81**Bb of the smooth surface of the coating layer **81**B corresponding to the front **80**Bb of the separator **80**B over which the recording medium S slides is produced with the plurality of recesses **81***a*, **81***b*, and **81***c* extending in a width direction of the separator **80**B parallel to an axial direction of the pressing roller **71** and orthogonal to the recording medium conveyance direction DS throughout substantially the entire width of the separator **80**B in the width direction thereof.

With reference to FIG. **7**, a description is provided of a construction of a fixing device **5**S according to a second example embodiment.

FIG. **7** is a vertical sectional view of the fixing device **5**S. Unlike the fixing device **5** depicted in FIG. **2**, the fixing device **5**S depicted in FIG. **7** includes a fixing assembly **50**A instead of the fixing assembly **50**. As shown in FIG. **7**, the fixing assembly **50**A includes an endless fixing belt **51**C; a fixing roller **51**A and a heating roller **51**B across which the fixing belt **51**C is stretched; and a heater **52** disposed inside the heating roller **51**B to heat the fixing belt **51**C via the heating roller **51**B.

As the cam **90** lifts the lever **91**, the lever **91** presses the pressing roller **71** against the fixing roller **51**A via the fixing belt **51**C to form the fixing nip N between the pressing roller **71** and the fixing belt **51**C. The fixing roller **51**A rotating in the rotation direction R**1** rotates the fixing belt **51**C in a rotation direction R**3**. As the fixing belt **51**C rotating in the rotation direction R**3** and the pressing roller **71** rotating in the rotation direction R**2** convey a recording medium S bearing a toner image IT through the fixing nip N, the fixing belt **51**C and the pressing roller **71** apply heat and pressure to the recording medium S, fixing the toner image IT on the recording medium S. The temperature sensor **53** includes a plurality of sensors disposed opposite an outer circumferential surface of the fixing belt **51**C at a center and a lateral end of the fixing belt **51**C in an axial direction thereof, thus detecting the temperature of the center and the lateral end of the fixing belt **51**C.

In order to facilitate separation of the recording medium S from the fixing belt **51**C, a hardness of the fixing roller **51**A is smaller than that of the pressing roller **71**. Thus, the harder pressing roller **71** presses against the softer fixing roller **51**A to contour the fixing nip N to fit into a curve of the pressing roller **71**. Accordingly, the curve of the pressing roller **71** directs the recording medium S discharged from the fixing nip N downward toward the pressing roller **71**. Consequently, the recording medium S does not adhere to the fixing belt **51**C.

The smaller hardness of the fixing roller **51**A increases the coefficient of thermal expansion of the fixing roller **51**A. Hence, as the temperature of the fixing roller **51**A fluctuates, the diameter of the fixing roller **51**A is subject to change. Accordingly, although a given slight interval C is produced between the front **80**Ab of a separation assembly **800**AS and the outer circumferential surface of the fixing belt **51**C, the slight interval C may change as the fixing roller **51**A thermally expands. To address this circumstance, the fixing device **5**S has a configuration that reduces change of the slight interval C as below.

FIG. **8** is a partial plan view of the fixing device **5**S illustrating a part of the fixing belt **51**C that contacts the fixing roller **51**A. A recording medium conveyance span CS defines a span spanning in the axial direction of the fixing belt **51**C on the outer circumferential surface thereof where the recording medium S is conveyed. That is, the recording medium conveyance span CS corresponds to a width of the recording medium S in the axial direction of the fixing belt **51**C. The fixing device **5**S includes a bracket **900** serving as a support that supports the separation assembly **800**AS including a plurality of separators, that is, four separators **80**A**1**, **80**A**2**, **80**A**3**, and **80**A**4**. The four separators **80**A**1**, **80**A**2**, **80**A**3**, and **80**A**4** are attached to and supported by the bracket **900**.

Each of the four separators **80**A**1**, **80**A**2**, **80**A**3**, and **80**A**4** has a configuration similar to that of the separator **80**A shown in FIG. **3** and is attached to the bracket **900** with the mechanism shown in FIG. **3**, that includes the pin **83**A, the spring **84**A, and the screw **85**A. However, the bracket **900** has a configuration different from that of the bracket **82**A shown in FIG. **3**.

With reference to FIG. **8**, a detailed description is now given of a configuration of the bracket **900**.

The bracket **900** is constructed of a body **903** disposed opposite the fixing belt **51**C and two arms **901** and **902** projecting from the body **903** at both lateral ends of the body **903** in the axial direction of the fixing belt **51**C toward the fixing belt **51**C. The arms **901** and **902** contact the fixing belt **51**C in non-conveyance spans NS on the outer circumferential surface of the fixing belt **51**C that are disposed outboard from the conveyance span CS in the axial direction of the fixing belt **51**C. The recording medium S is not conveyed in the non-conveyance spans NS. As the fixing roller **51**A thermally expands, the bracket **900** having the arms **901** and **902** in contact with the fixing belt **51**C moves in accordance with thermal expansion of the fixing roller **51**A. Accordingly, the slight interval C is retained constantly between the front **80**Ab of the respective separators **80**A**1**, **80**A**2**, **80**A**3**, and **80**A**4** and

the outer circumferential surface of the fixing belt **51**C. Consequently, even if the fixing roller **51**A thermally expands, the separators **80**A**1**, **80**A**2**, **80**A**3**, and **80**A**4** maintain their performance of separating the recording medium S from the fixing belt **51**C.

Additionally, since the bracket **900** retains the constant slight interval C between the separators **80**A**1**, **80**A**2**, **80**A**3**, and **80**A**4** and the fixing belt **51**C, the recording medium S slides over the separators **80**A**1**, **80**A**2**, **80**A**3**, and **80**A**4** with a constant friction, reducing variation in gloss of the toner image IT caused by friction between the recording medium S and the separators **80**A**1**, **80**A**2**, **80**A**3**, and **80**A**4**. Further, acute streaks, a caterpillar pattern, and variation in gloss of the toner image IT regularly produced in the recording medium conveyance direction DS are suppressed effectively.

According to this example embodiment, the bracket **900** supports the four separators **80**A**1**, **80**A**2**, **80**A**3**, and **80**A**4** as one example. Alternatively, the number of separators supported by the bracket **900** may be three or less or five or more. Yet alternatively, the bracket **900** may be employed by the fixing device **5** depicted in FIG. **2** instead of the bracket **82**A depicted in FIG. **3**.

Each of the separators **80**A**1**, **80**A**2**, **80**A**3**, and **80**A**4** has a configuration similar to that of the separator **80**A depicted in FIGS. **3** to **5**. That is, each of the separators **80**A**1**, **80**A**2**, **80**A**3**, and **80**A**4** mounts the recesses **81***a*, **81***b*, and **81***c* shaped and positioned as shown in FIGS. **4** and **5**.

As shown in FIG. **4**, the three recesses **81***a*, **81***b*, and **81***c* are produced in the coating layer **81**A. The recesses **81***a*, **81***b*, and **81***c* are curved to project downward in FIG. **4**. For example, the recesses **81***a*, **81***b*, and **81***c* are curved to project toward an edge of the separator **80**A that is disposed opposite the fixing roller **51** depicted in FIG. **2** or the fixing belt **51**C depicted in FIG. **7** or toward the fixing nip N from which the recording medium S is conveyed in the recording medium conveyance direction DS to the separator **80**A. It is because, if the recesses **81***a*, **81***b*, and **81***c* are straight along the width direction W**1** of the separator **80**A orthogonal to the recording medium conveyance direction DS, a step height of the respective recesses **81***a*, **81***b*, and **81***c* may impose load to the recording medium S sliding over the separator **80**A, degrading conveyance of the recording medium S separated from the fixing roller **51** by the separator **80**A. To address this circumstance, the recesses **81***a*, **81***b*, and **81***c* are curved to project toward the fixing nip N so that a leading edge of the recording medium S is not stuck in steps of the recesses **81***a*, **81***b*, and **81***c* simultaneously throughout a longitudinal direction of the recesses **81***a*, **81***b*, and **81***c* parallel to the axial direction of the fixing roller **51**, thus facilitating conveyance of the recording medium S.

With reference to FIG. **9**, a description is provided of the shape of the recesses **81***a*, **81***b*, and **81***c*.

FIG. **9** is a partial vertical sectional view of the separator **80**A. As shown in FIG. **9**, as seen in a direction orthogonal to the recording medium conveyance direction DS, the recesses **81***a* and **81***b* produced in the coating layer **81**A are arc-shaped in cross-section.

A first angle θa is formed between a first slope **81S1** of the coating layer **81**A, corresponding to a front edge of the separator **80**A, and a conveyance face **81**Ac of the coating layer **81**A, over which the recording medium S slides, in cross-section. A second angle θb is formed between a second slope **81S2** of the coating layer **81**A, contiguous to and disposed downstream from the first slope **81S1** in the recording medium conveyance direction DS, and the conveyance face **81**Ac, in cross-section. The first angle θa closer to the fixing roller **51** than the second angle θb is greater than the second angle θb.

With reference to FIG. **10**, a description is provided of the length of the respective recesses **81***a*, **81***b*, and **81***c* in the recording medium conveyance direction DS.

FIG. **10** is a partial plan view of the separator **80**A. As shown in FIG. **10**, the greater the angle formed between the slope and the conveyance face **81**Ac of the coating layer **81**A is, the smaller the length of the recess in the recording medium conveyance direction DS produced in the slope is.

For example, since the first angle θa formed between the first slope **81S1** and the conveyance face **81**Ac of the coating layer **81**A is greater than the second angle θb formed between the second slope **81S2** and the conveyance face **81**Ac of the coating layer **81**A, a first length Wa of the recess **81***a* in the recording medium conveyance direction DS, that is, a first recess produced in the first slope **81S1** that forms the greater first angle θa with the conveyance face **81**Ac, is smaller than a second length Wb of the recess **81***b* in the recording medium conveyance direction DS, that is, a second recess produced in the second slope **81S2** that forms the smaller second angle θb with the conveyance face **81**Ac.

An adhesive force of the solid toner image IT on the recording medium S to adhere to the coating layer **81**A is relatively small in proximity to the recess **81***a* produced in the first slope **81S1** that forms the greater first angle θa with the conveyance face **81**Ac. Contrarily, an adhesive force of the solid toner image IT on the recording medium S to adhere to the coating layer **81**A is relatively great in proximity to the recess **81***b* produced in the second slope **81S2** that forms the smaller second angle θb with the conveyance face **81**Ac. To address this circumstance, the second length Wb of the recess **81***b* is greater than the first length Wa of the recess **81***a* in the recording medium conveyance direction DS to decrease the area of the slide surface of the coating layer **81**A over which the recording medium S slides, thus decreasing the adhesive force of the solid toner image IT on the recording medium S to adhere to the coating layer **81**A. Accordingly, the adhesive force of the solid toner image IT to adhere to the coating layer **81**A is constant regardless of variation of the first angle θa and the second angle θb, stably suppressing acute streaks, a caterpillar pattern, and variation in gloss of the toner image IT regularly produced in the recording medium conveyance direction DS.

FIG. **9** illustrates the two recesses **81***a* and **81***b*. Alternatively, the number of the recesses may be three or more. In this case also, as the angle formed between the slope and the conveyance face **81**Ac of the coating layer **81**A increases, the length of the recess in the recording medium conveyance direction DS produced in the slope decreases.

For example, FIG. **10** illustrates the three recesses **81***a*, **81***b*, and **81***c* and the length thereof in the recording medium conveyance direction DS. As shown in FIG. **10**, the first length Wa of the recess **81***a* is smaller than the second length Wb of the recess **81***b* disposed downstream from the recess **81***a* in the recording medium conveyance direction DS. The second length Wb of the recess **81***b* is smaller than a third length Wc of the recess **81***c* disposed downstream from the recess **81***b* in the recording medium conveyance direction DS.

As shown in FIG. **9**, a first depth Da of the recess **81***a* having the smaller first length Wa is greater than a second depth Db of the recess **81***b* having the greater second length Wb. As shown in FIG. **10**, since the first length Wa of the recess **81***a* is smaller than the second length Wb of the recess **81***b* that is smaller than the third length Wc of the recess **81***c*,

the first depth Da of the recess **81***a* is greater than the second depth Db of the recess **81***b* that is greater than a third depth Dc of the recess **81***c*.

If the second depth Db of the recess **81***b* having the greater second length Wb is greater than the first depth Da of the recess **81***a* having the smaller first length Wa, the leading edge of the recording medium S conveyed from the fixing nip N may be stuck in the deeper recess **81***b*. To address this problem, according to this example embodiment, the recess **81***b* having the greater second length Wb has the smaller second depth Db.

With reference to FIGS. **11**A and **11**B, a description is provided of results of an experiment to examine a relation between the roughness of the coating layer **81**A coating the front **80**Ab of the separator **80**A and appearance of acute streaks and a caterpillar pattern on the toner image IT on the recording medium S caused by the separator **80**A.

FIG. **11**A is a graph showing a relation between the maximum height of the coating layer **81**A and the rank of acute streaks that appear on the toner image IT on the recording medium S sliding over the coating layer **81**A. The horizontal axis (x-axis) represents the maximum height Rz (μm) of the coating layer **81**A. The vertical axis (y-axis) represents the rank of visually checked acute streaks that appear on the toner image IT on the recording medium S. Rank 4 or above defines no acute streaks visually identified.

The experiment was performed at three temperatures of the outer circumferential surface of the fixing roller **51**, that is, a given temperature □, a temperature Δ lower than the given temperature □ by 5 degrees centigrade, and a temperature ◇ higher than the given temperature □ by 5 degrees centigrade. As shown in FIG. **11**A, with the maximum height of the coating layer **81**A of 15 μm Rz or smaller, acute streaks appear at none of the three temperatures of the fixing roller **51**. This means that the coating layer **81**A having the maximum height of 15 μm Rz or smaller as the surface roughness parameter prevents acute streaks.

FIG. **11**B is a graph showing a relation between the ten point average roughness Rzjis and the rank of a caterpillar pattern that appears on the toner image IT on the recording medium S sliding over the coating layer **81**A. The horizontal axis (x-axis) represents the ten point average roughness Rzjis of the coating layer **81**A. The vertical axis (y-axis) represents the rank of a caterpillar pattern that appears on the toner image IT on the recording medium S. Rank 5 defines no caterpillar pattern appearing on the toner image IT. The coating layer **81**A having the ten point average roughness Rzjis of 10 or more prevents a caterpillar pattern.

The experiment results illustrated in FIGS. **11**A and **11**B show that the coating layer **81**A having the maximum height Rz of 15 μm or smaller and the ten point average roughness Rzjis of 10 or greater prevents acute streaks even without the recesses **81***a*, **81***b*, and **81***c*. However, the coating layer **81**A made of fluoroplastic may be subject to abrasion by friction between the coating layer **81**A and the toner image IT on the recording medium S sliding over the coating layer **81**A. To address this circumstance, according to the example embodiments described above, the coating layer **81**A has the maximum height Rz of 15 μm or smaller and is produced with the plurality of recesses (e.g., at least two of the recesses **81***a*, **81***b*, and **81***c*), preventing acute streaks and a caterpillar pattern effectively.

Since general coating layers made of fluoroplastic have a thickness of about 30 μm or greater, the maximum depth of each of the recesses **81***a*, **81***b*, and **81***c* may be about 30 μm or greater. It is to be noted that the thickness of the coating layer **81**A is exaggerated for purposes of illustration in FIG. **9**. Therefore, the depths Da and Db of the recesses **81***a* and **81***b* produced in the coating layer **81**A are illustrated smaller relative to the thickness of the coating layer **81**A.

With reference to FIGS. **2**, **4**, **7**, and **8**, a description is provided of advantages of the fixing devices **5** and **5**S.

The fixing device (e.g., the fixing devices **5** and **5**S) includes a fixing assembly (e.g., the fixing assemblies **50** and **50**A) including a fixing rotary body (e.g., the fixing roller **51** and the fixing belt **51**C) rotatable in a given direction of rotation (e.g., the rotation directions R**1** and R**3**); a heater (e.g., the heater **52**) disposed opposite and heating the fixing rotary body; a pressing rotary body (e.g., the pressing roller **71**) pressed against the fixing rotary body to form the fixing nip N therebetween through which a recording medium S bearing a toner image IT is conveyed; and at least one separator (e.g., the separators **80**A, **80**A**1**, **80**A**2**, **80**A**3**, and **80**A**4**) disposed opposite the fixing rotary body to separate the recording medium S discharged from the fixing nip N from the fixing rotary body, thus preventing the recording medium S from being wound around the fixing rotary body. The separator includes the front **80**Ab disposed opposite an outer circumferential surface of the fixing rotary body with a given interval (e.g., the slight intervals A and C) therebetween and the conveyance face **80**Ac contiguous to the front **80**Ab, over which the recording medium S slides.

The separator is coated with the smooth coating layer **81**A, made of fluoroplastic, that coats at least the front **80**Ab and the conveyance face **80**Ac of the separator. A part, that is, the front portion **81**Ab of the smooth surface of the coating layer **81**A corresponding to the front **80**Ab of the separator is produced with the plurality of recesses **81***a*, **81***b*, and **81***c* extending in the width direction W**1** of the separator orthogonal to the recording medium conveyance direction DS throughout substantially the entire width of the separator in the width direction W**1** thereof.

Accordingly, the plurality of recesses **81***a*, **81***b*, and **81***c* prevents acute streaks, a caterpillar pattern, and variation in gloss of the toner image IT regularly produced in the recording medium conveyance direction DS that may be produced on the toner image IT by the separator as the recording medium S slides over the separator.

According to the example embodiments described above, the pressing roller **71** serves as a pressing rotary body in contact with the fixing roller **51** or the fixing belt **51**C. Alternatively, a pressing belt, pressing pad, a pressing plate, or the like may serve as a pressing rotary body.

The present invention has been described above with reference to specific example embodiments. Note that the present invention is not limited to the details of the embodiments described above, but various modifications and enhancements are possible without departing from the spirit and scope of the invention. It is therefore to be understood that the present invention may be practiced otherwise than as specifically described herein. For example, elements and/or features of different illustrative example embodiments may be combined with each other and/or substituted for each other within the scope of the present invention.

What is claimed is:

1. A fixing device comprising:

a fixing rotary body rotatable in a given direction of rotation;

a pressing rotary body pressed against the fixing rotary body to form a fixing nip therebetween through which a recording medium is conveyed;

a separator disposed downstream from the fixing nip in a recording medium conveyance direction to separate the recording medium discharged from the fixing nip from the fixing rotary body,

the separator including:

a front disposed opposite an outer circumferential surface of the fixing rotary body with a given interval therebetween; and

a conveyance face contiguous to the front, over which the recording medium slides; and

a coating layer, made of fluoroplastic, to coat the front and the conveyance face of the separator,

the coating layer including a front portion corresponding to the front of the separator and disposed opposite the recording medium, the front portion produced with a plurality of recesses extending in a width direction of the separator orthogonal to the recording medium conveyance direction throughout substantially an entire width of the separator in the width direction thereof.

2. The fixing device according to claim **1**, further comprising a heater disposed opposite and heating the fixing rotary body,

wherein the fixing rotary body includes a fixing roller.

3. The fixing device according to claim **1**, wherein the fixing rotary body includes an endless fixing belt.

4. The fixing device according to claim **3**, further comprising:

a fixing roller pressing against the pressing rotary body via the fixing belt;

a heater disposed opposite and heating the fixing belt; and

a heating roller disposed opposite the heater,

wherein the fixing belt is stretched across the fixing roller and the heating roller.

5. The fixing device according to claim **1**, wherein the pressing rotary body includes a pressing roller.

6. The fixing device according to claim **1**, further comprising a support to support the separator and including a plurality of arms projecting from both lateral ends of the support in an axial direction of the fixing rotary body, respectively, toward the fixing rotary body, the arms contacting the fixing rotary body to retain the given interval between the separator and the fixing rotary body.

7. The fixing device according to claim **6**, wherein the arms of the support contact the fixing rotary body in non-conveyance spans, where the recording medium is not conveyed, disposed at both lateral ends on the outer circumferential surface of the fixing rotary body in the axial direction thereof.

8. The fixing device according to claim **6**, wherein the support includes a bracket.

9. The fixing device according to claim **8**, further comprising a pin attached to the bracket and pivotably supporting the separator.

10. The fixing device according to claim **1**, wherein each of the plurality of recesses produced in the coating layer is arc-shaped in cross-section.

11. The fixing device according to claim **1**,

wherein the front portion of the coating layer has a smooth surface having a maximum height not greater than about 15 μm Rz, and

wherein each of the plurality of recesses has a depth not smaller than about 30 μm.

12. The fixing device according to claim **1**,

wherein the front portion of the coating layer includes:

a first slope disposed opposite the fixing rotary body with the given interval therebetween; and

a second slope contiguous to and disposed downstream from the first slope in the recording medium conveyance direction, and

wherein a first angle formed between the first slope of the coating layer and the conveyance face of the separator in cross-section is greater than a second angle formed between the second slope of the coating layer and the conveyance face of the separator in cross-section.

13. The fixing device according to claim **12**,

wherein the plurality of recesses includes:

a first recess produced in the first slope and having a first length in the recording medium conveyance direction; and

a second recess produced in the second slope and having a second length in the recording medium conveyance direction, and

wherein the first length of the first recess is smaller than the second length of the second recess.

14. The fixing device according to claim **13**, wherein the first recess has a first depth that is greater than a second depth of the second recess.

15. The fixing device according to claim **1**, wherein each of the plurality of recesses is curved to project toward an edge of the separator that is disposed opposite the fixing rotary body.

16. The fixing device according to claim **1**, wherein the separator is made of at least one of heat-resistant, rigid resin and metal.

17. An image forming apparatus comprising the fixing device according to claim **1**.

18. The fixing device according to claim **1**, further comprising another separator.

19. The fixing device according to claim **18**, wherein each of the separators has the plurality of recesses.

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